TIME VALUE OF WATER

Introduction

Freshwater flow in the Sacramento-San Joaquin Delta and River system provides essential ecological benefits and is the primary source of water to agriculture, numerous municipalities, and industries. Ecological benefits of freshwater flow or impacts of freshwater diversions vary with season and location. Planning for ways to improve the system needs to consider these temporal and spatial variations of the value of water. Methods are needed to analyze:

- The best use of additional environmental water as it becomes available, and
- When additional water diversions would have the least environmental effect.

The concept of time value of water is the foundation of the approach that the CALFED Bay-Delta Program (CALFED) is using to address these issues. Time value of water is a concept that expresses the relative ecological value of water as it relates to instream flow and diversions at specific locations throughout the Sacramento-San Joaquin Delta and River system. Time-value relationships will be used to provide a big-picture but gross scale estimate of what may be possible to accomplish.

The development of the detailed time-value approach will take full advantage of expert understanding of the life history and behavioral adaptations of aquatic life to variable flow conditions that is available in the CALFED agencies and within the stakeholder community. These aquatic habitat experts also recognize that there are many additional factors that interact with flows and affect aquatic organisms. For example, maintenance of channel shape, water temperature, and occurrence of pulse flows are important factors that need to be considered.

This document describes the concept of time value and the methods that will be used to develop the time-value relationships for both increased environmental flow and increased diversion. It also describes the next steps in the process that will be followed for implementation of the methodology.

Time-Value Method for Assessing the Benefits of Increased Environmental Flows

The time-value method for assessing the benefits of increased flows consists of the four steps summarized in Figure 1.

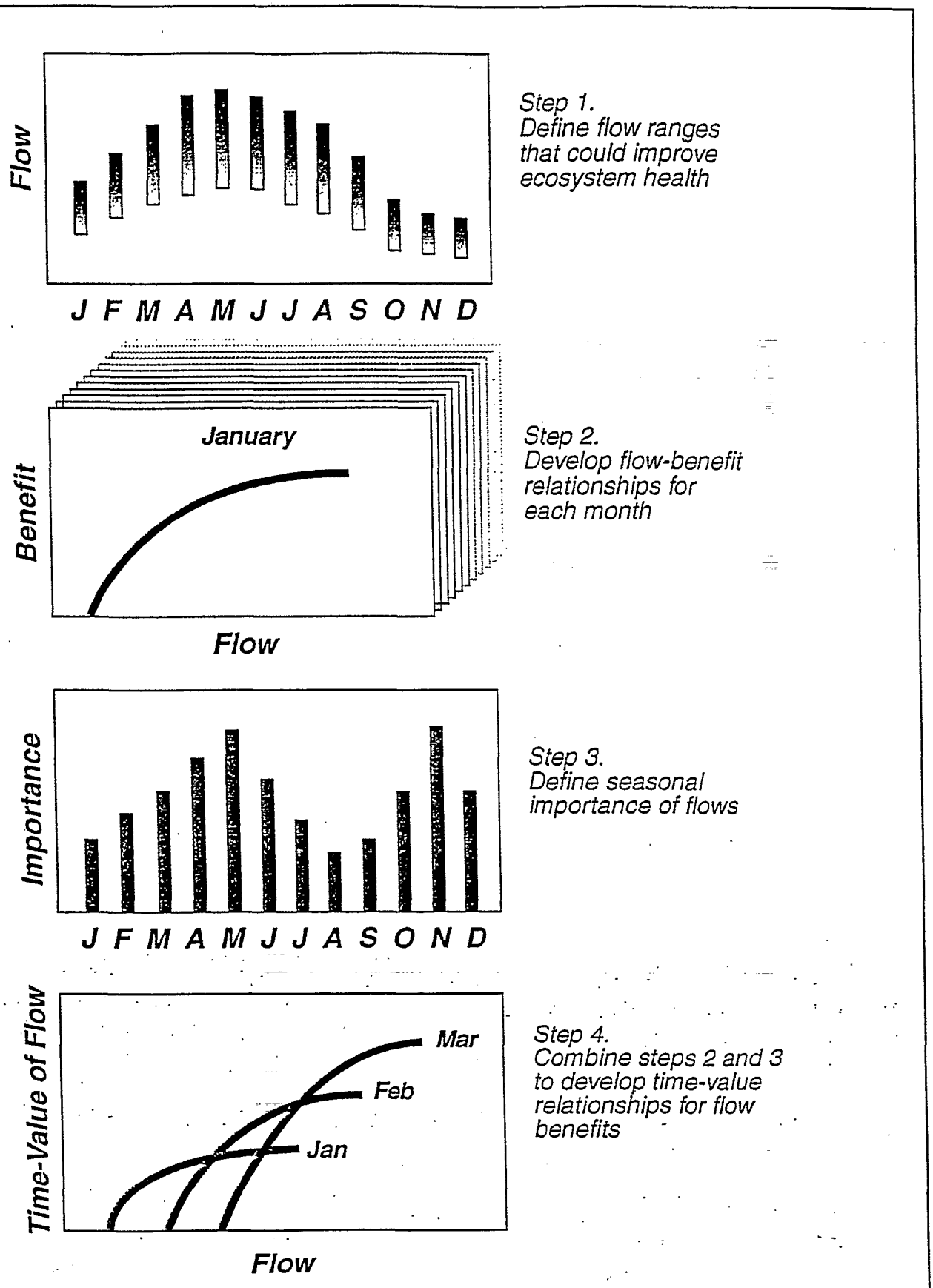

Figure 1. Overview of Time-Value concept for evaluating benefits of increased environmental flows.

The first step is to define the range of flows that could affect the health of the ecosystem. Upper and lower limits are assigned for each month. The lower limit represents a minimal baseline flow that is required for all important species to sustain health. The upper limit represents the flow that will provide optimal ecological conditions. Further significant ecological benefits will not be obtained by increasing flows above this limit. The upper and lower limits can be established by looking at historical records of unimpaired flows and current flow conditions, and combining this information with knowledge of fish life history requirements. The flow ranges are selected on a monthly basis to accommodate seasonal differences in the needs of the fish, as well as natural seasonal variability in the hydrologic cycle.

The second step is to define the flow-benefit relationships for each month. These describe the incremental benefits that will be obtained by increasing flows within the ranges established in Step 1. In general, benefits initially increase rapidly as flow begins to increase over the minimum value required for survival. However, as the flows get larger and approach the upper flow limit, the incremental benefits increase at a much slower rate. This relationship is described by a curve, which is initially steep, but then flattens out as the upper flow limit is approached. The shape of this curve will be determined by resource experts using the life histories and habitat requirements for all important fish species. Separate flow-benefit relationships will be constructed for each month since the flow ranges and fish needs vary from month to month.

The third step is to assign a weighting factor for each month that describes how important it is to maintain flows during that month compared to the other months of the year. The weighting factors depend on the life cycles of the fish and on how critical flow conditions are to their survival and reproduction. A high value would be assigned to months where maintaining adequate flows is extremely important, for example, during spawning seasons, while a low value would be assigned to other periods when fish are less sensitive to flows or are not abundant in the area.

The fourth step combines the information obtained in the previous steps. The flow-benefit relationships developed in Step 2 are multiplied by the monthly weighting factors developed in Step 3. The objective is to bring the importance of seasonal variation in the vulnerability of fish into the monthly flow-benefit relationships. The result is a series of monthly flow-benefit relationships from a minimum value of zero at the minimum flow required to sustain fish health to a maximum value that equals the monthly weighting factor. This series of curves establishes the time-value relationships for assessing the ecological benefits of additional flow increments at a particular location.

Flow benefit relationships will be developed at several locations throughout the Sacramento-San Joaquin Delta and River system. Additional weighting factors will be applied at each location to account for differences in the relative benefits of increasing flows at different locations. This will produce a set of time-value curves that allow the values of increased flows to be compared at different locations and times using a consistent methodology.

Time-Value Method for Assessing the Impacts of Increased Diversions

The time-value method for assessing the relative impacts of flow diversions is similar to the approach described above for assessing the benefits of increased flows. It consists of the four steps summarized in Figure 2.

The first step is to define the range of diversion flows that will be considered in the diversion impact analysis. The lower limit could be zero to represent no diversions, or could be set at some other level representing the minimum diversion levels that currently exist. The upper limit is the maximum fraction of diverted flow which is under consideration. This could be constrained by the limits of current pumping facilities, or could reflect maximum diversion levels being considered for the future.

The second step is to define diversion-impact relationships for each month. These describe the incremental impacts that will occur as the fraction of river flow being diverted increases. The shapes of the diversion impact curves will be determined by resource experts using information on fish life histories that influence their vulnerability to diversion impacts. These curves could have a variety of shapes, depending on how much the incremental impacts increase with additional flow diversions. They could include both the direct impacts of entrainment or impingement on screens, as well as the indirect effects of flow reductions associated with diversions.

The third step is to assign a weighting factor for each month that describes the potential severity of fishery impacts during that month compared to other months of the year. The weighting factors are based on the same diversion flow volume for each month to allow valid comparisons between months. Monthly impact severity is determined by both seasonal differences in fish abundance near the diversion facility and by life history characteristics that make some life stages or portions of the life cycle more vulnerable to diversion impacts than others. Any units can be used for assigning the monthly weighting factors as long as they are consistently applied at all months and locations.

The final step is to combine the information in the previous steps for each month. The diversion-impact relationships developed in Step 2 are multiplied by the monthly weighting factors developed in Step 3. This produces a series of time-value relationships that incorporates information on seasonal variation in fish abundance together with life cycle characteristics that affect their vulnerability to diversion impacts.

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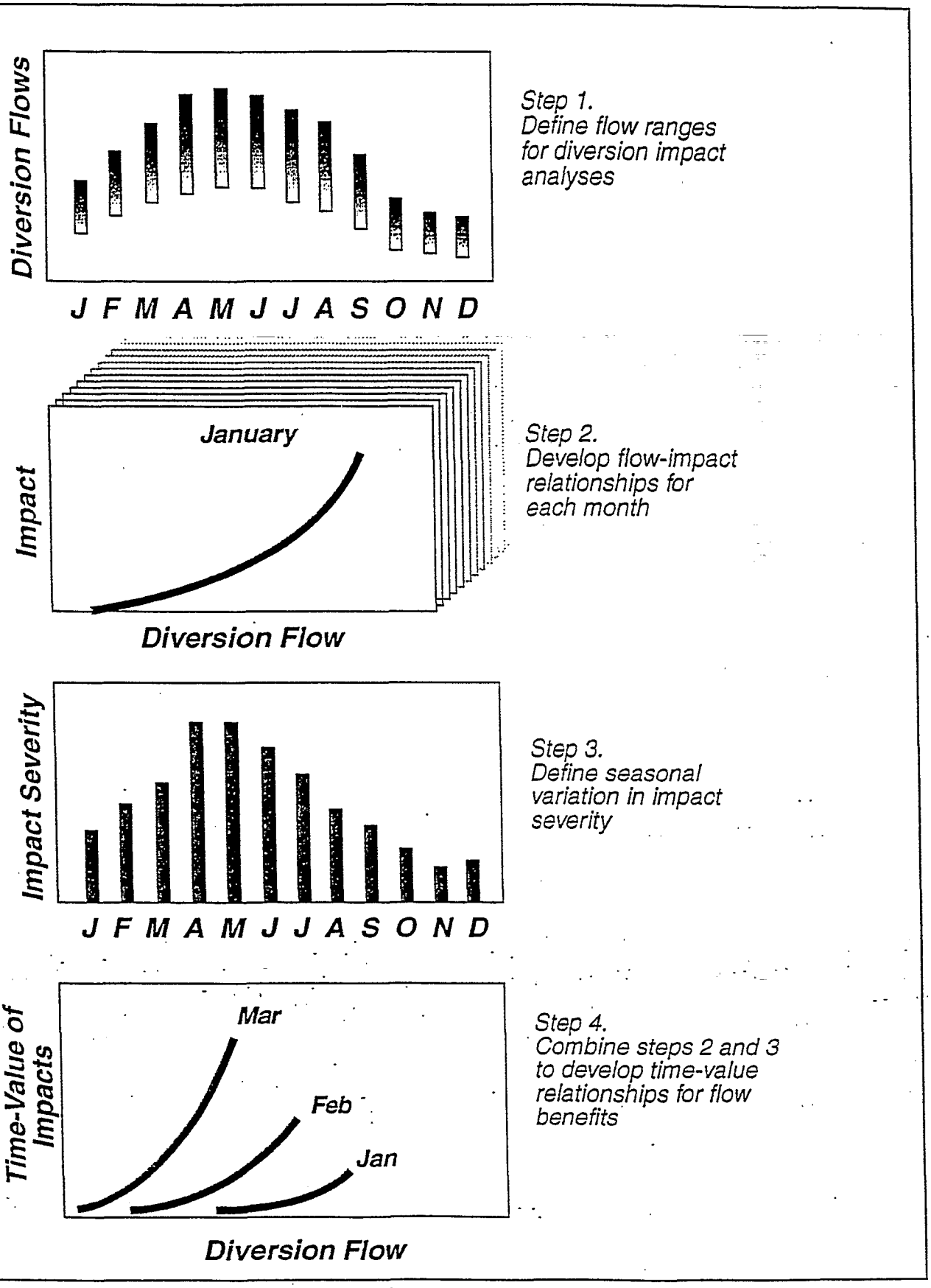

Figure 2. Overview of Time-Value concept for evaluating benefits of increased diversions.

Next Steps in the Process

Additional work is needed to develop the time-value methodology before it can be used effectively in the evaluation of the planning alternatives identified by CALFED. A detailed description of the time-value methods will be prepared. The concepts, underlying assumptions and mathematical formulations will be described. An example application will be presented that demonstrates the steps in developing the time-value relationships.

Groups of experts from the agencies and stakeholders will be invited to provide their expertise in establishing the time-value relationships. Participation by all stakeholders, including the local experts with special knowledge of the individual river basins, will help assure that the best possible estimates are obtained.

A database of biological, hydrologic, and geomorphic data will be developed to facilitate input. The experts will be asked to provide their estimates of appropriate instream or diversion flow ranges, flow-benefit and diversion-impact relationships, monthly weighting factors, and individual time-value relationships.

The individual time-value results will be compiled. Individual results will be compared for consistency, and follow-up questioning will be used to reconcile differences. Then, results from all of the experts will be combined to obtain the overall time-value relationships.

Next, the time-value relationships will be tested. Historical data and simulated conditions will be used to test the performance of the methods under a variety of situations. The test results will be used to modify and refine the time-value methods.

Finally, the time-value relationships can be used to help plan for the best use of increased environmental water and the best ways to minimize impacts of increased diversions.